



Polycyclic aromatic hydrocarbons in sediments and fish species from the White Nile, East Africa: Bioaccumulation potential, source apportionment, ecological and health risk assessment

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INTRODUCTION

Polycyclic aromatic hydrocarbons (PAHs) in the environment are of global concern due to their ubiquity, environmental persistence, long-range transport, toxicity, and potential adverse effects on human health and the environment.

The White Nile River being part of the Nile River system, and close to Merut oil fields, presents a suitable case to understand the dynamics and impact of PAH pollution.

The objectives of this study were to [1] establish levels and sources of PAHs in sediments and fish species from a section of White Nile, [2] identify the processes and mechanisms that drive the accumulation of PAHs in sediments and fish, [3] estimate bioaccumulation potential of the pollutants in the fish relative to the sediments, and [4] estimate the potential human health risks posed through consumption of fish contaminated with PAHs.

MATERIALS AND METHODS

Study area and sampling

The study area was a section of White Nile River which is located in vicinity of Melut town (10.440° N, 32.202° E), in South Sudan's Upper Nile state (Fig.1).

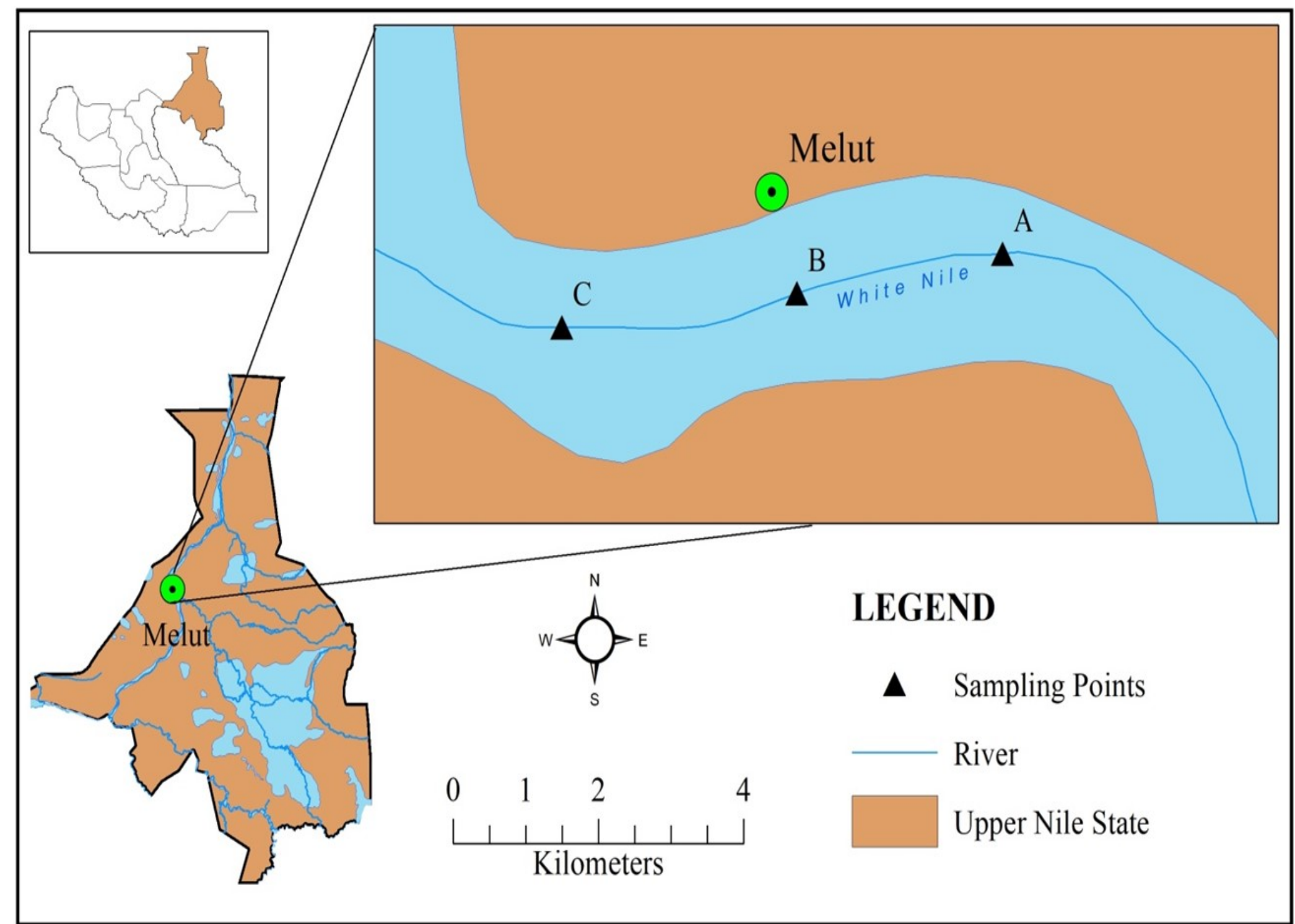
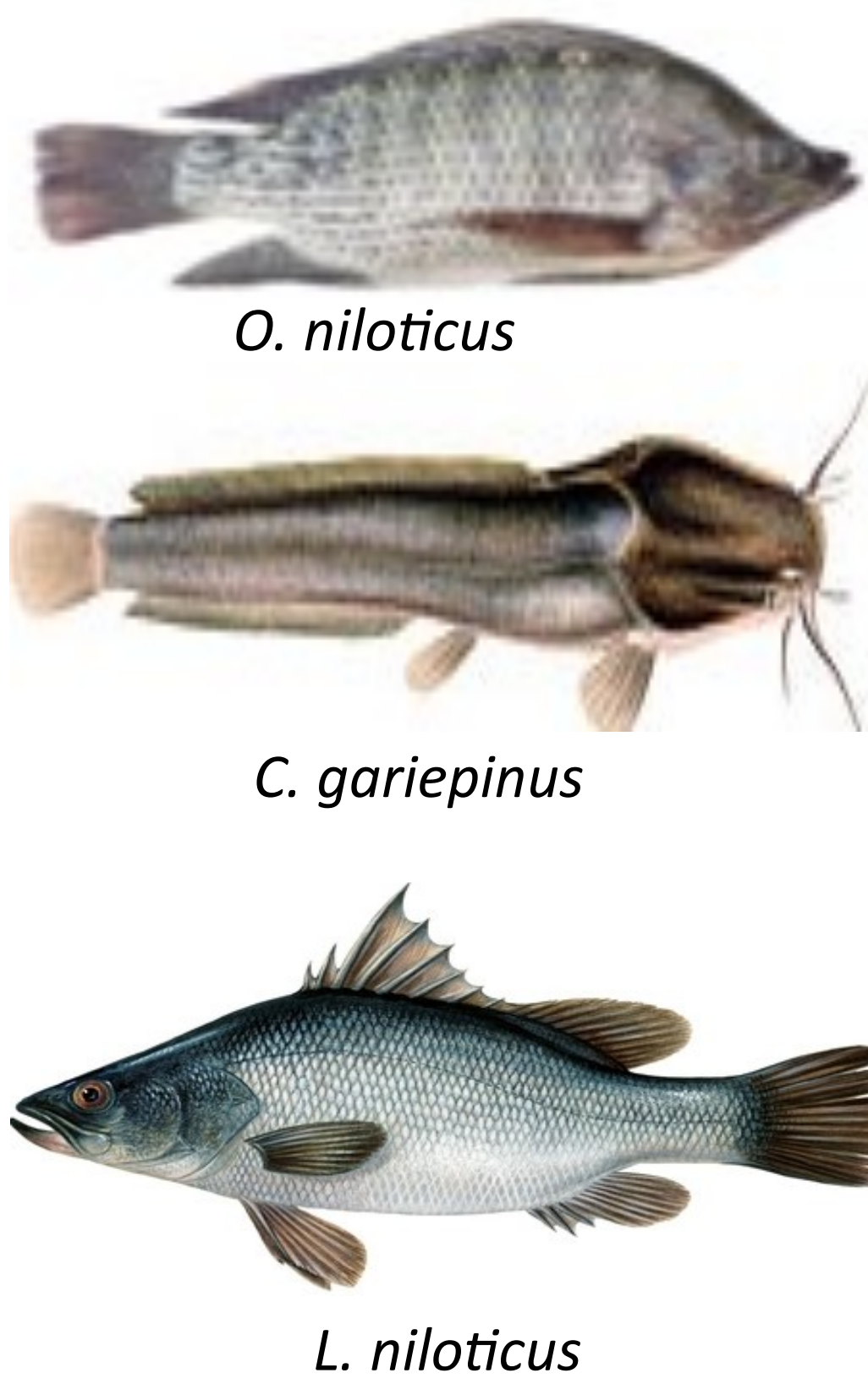


Fig. 1: Map showing the study sites

Analytical procedures on the samples

- Extraction was done using an ultrasonic bath as reported by Sun et al. (2016) for sediments and Yu et al. (2016) for fish samples.
- Cleanup of extracts was done using a multi-layer silica gel column.
- Instrumental analysis was done using GC-MS.

Fish species



Estimation of accumulation of the PAHs in fish relative to sediments

- Biota-sediment accumulation factors (BSAFs) was calculated as reported by Burkhard (2009).

Identification of PAHs sources in sediments

- Diagnostic ratios such as Flt/(Flt+Pyr), Σ LPAHs/ Σ HPAHs were calculated as described by Tobiszewski & Namiesnik (2012).
- Principal component analysis (PCA) was also used in addition to DRs and source markers.

RESULTS AND DISCUSSION

Levels of PAHs in the sediments and fish

- Total (Σ_{13}) PAH concentrations ranged from 566 to 674 ng g⁻¹ dry weight (dw) in sediments, while those in fish were 191 – 1143 ng g⁻¹ wet weight (ww).
- Σ_{13} PAH concentrations were significantly higher in *C. gariepinus* than in other fish species.
- Low molecular weight PAHs (LPAHs) dominated the profile of PAHs in sediments (constituted 95% of Σ_{13} PAHs) and fish (97% of Σ_{13} PAHs) (Fig. 2).

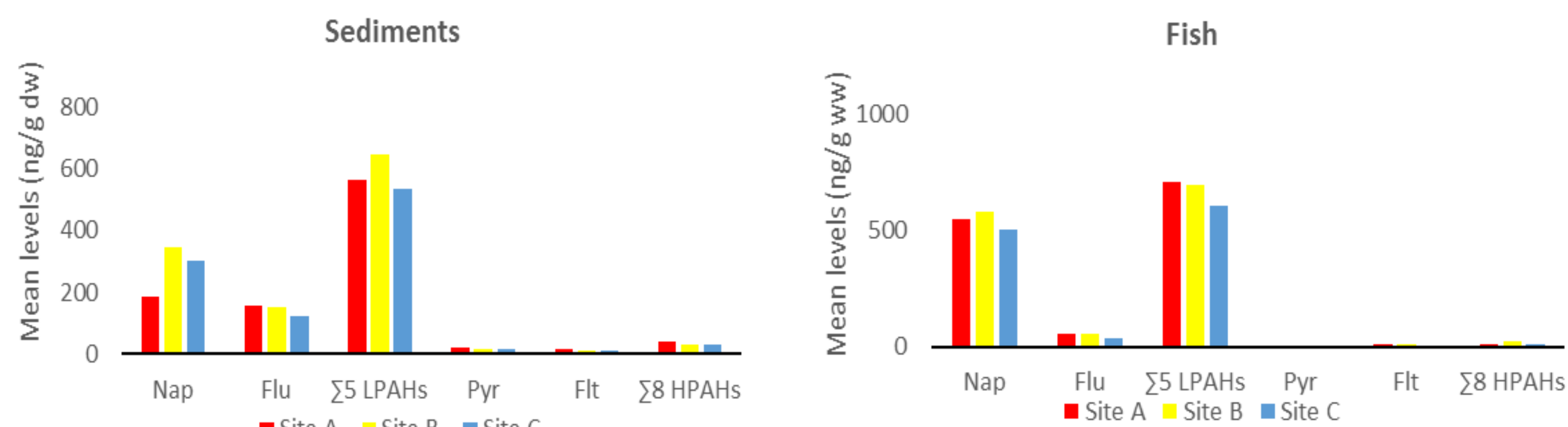


Fig. 2: Concentrations of PAHs in sediments and fish

- Compared to Sediment Quality Guidelines of the United States Oceanic and Atmospheric Administration, the levels of LPAHs in this study were all above the threshold effect limits, but below the probable effect level, while those of high molecular weight PAHs (HPAHs) were all below the lowest effect levels.
- The carcinogenic potency equivalent concentrations of PAHs in *L. niloticus* and *C. gariepinus* were above the US EPA screening level; suggesting consumption of these species could adversely affect human health.

Estimation of accumulation of PAHs in fish relative to sediments

- Biota-sediment accumulation factor values (range: 0.006 to 3.816 g OC g⁻¹ lipid) for PAHs showed high bioaccumulation of LPAHs in fish muscle, and that bioaccumulation decreased with increase in hydrophobicity of the compounds.

- This is possibly because LPAHs have higher aqueous solubilities which increases their bioavailability through water-gill transfers compared to HPAHs.

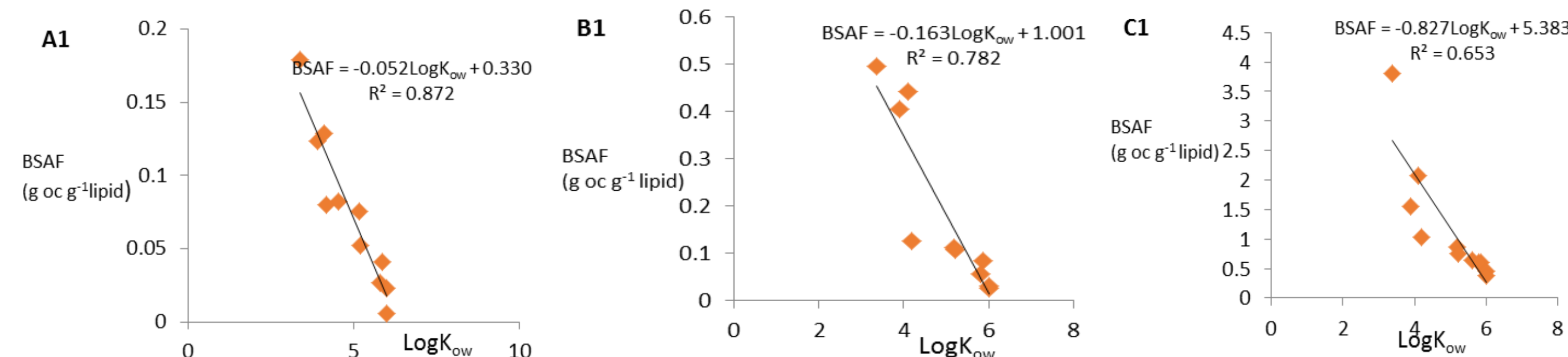


Fig 3: BSAFs for PAHs and their individual Log K_{ow} values for *L. niloticus* (A1, B1, C1) at sites A, B and C

Sources of PAHs in the Nile environment

- Profiles of PAHs in the White Nile environment indicate predominant contribution from petrogenic sources, which could be attributed to presence of crude oil reservoirs and oil production operations (Table 1).

Table 1: Diagnostic ratios of PAHs in sediments

Ratio	Petrogenic source	Pyrogenic source	Sampling sites		
			A	B	C
Σ LPAHs/ Σ HPAHs	>1	<1	17.66±9.48	28.14±20.85	16.95±11.70
Flt/(Flt + Pyr)	<0.4	>0.4	0.46±0.18	0.45±0.11	0.37±0.04
BaA/(BaA + Chr)	<0.35	>0.35	0.28±0.24	NA	0.16±0.09
BbF/BkF	<0.6	>0.6	0.39±0.19	2.84±0.17	3.25±0.61

Conclusions

- PAHs were detected in fish and sediments from White Nile, South Sudan.
- Low molecular weight PAHs were predominant in both fish and sediment samples.
- PAHs were mainly of petrogenic origin, pointing to oil production activities.
- BSAFs showed that bioaccumulation of LPAHs was higher than that of HPAHs.
- PAHs in some fish were high; could adversely affect human health upon consumption.

Future perspectives

More research into the levels of other environmental pollutants in the oil-rich area is recommended.

Contribution to the UN Sustainable development goals

The present project is geared towards goal 14 of the Sustainable Development Goals i.e., SDGs (conserve and sustainably use the oceans, seas and marine resources for sustainable development).

References

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